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Terrestrial gamma radiation dose rates (TGRD) from surface soil in Negeri Sembilan, Malaysia

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HIGHLIGHTS

- Isodose map of terrestrial gamma radiation dose rate measured from soil surface at Negeri Sembilan was plotted and is in the range of 71–1000 nGy/h.
- Study shows a close relationship between geological formations, soil type distribution and terrestrial gamma radiation dose rate measured.
- The annual effective dose to the population of Negeri Sembilan was calculated to be 0.96 mSv per year.

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ABSTRACT

Baseline data on background radiation levels allows for future assessment of possible changes in natural radionuclide concentrations, either as a result of geological processes or radioactive contamination. We have measured terrestrial gamma radiation dose-rates (TGRD) from surface soils throughout accessible areas in the Peninsular Malaysia state of Negeri Sembilan (NS). Dose rate measurements were carried out using a NaI (TI) scintillation survey meter, encompassing 1708 locations, covering about 73% of the 6645 km^2 of the land area in NS. This has allowed development of a TGRD contour map, plotted using WinSurf software. The range of measured TGRD was from 71 $\pm$ 3 nGy/h up to 1000 $\pm$ 11 nGy/h. The greatest measured TGRD was obtained in an area covered by soil types originating from igneous rock of granitic formations, while the least value of TGRD was observed in an area covered by limestone composed of calcite mineral, mostly found near river and coastal areas. Mean values of TGRD across the seven districts of NS ranged from 244 $\pm$ 7 nGy/h to 458 $\pm$ 13 nGy/h, the global mean being 330 $\pm$ 8 nGy/h compared to a mean value of 92 nGy/h and 59 nGy/h for Malaysia and the world, respectively. The average annual dose from such terrestrial gamma radiation dose-rates to an individual residing in NS, assuming a tropical rural setting, is estimated to be 0.96 mSv per year.

1. Introduction

Naturally occurring terrestrial radiation is ubiquitous, environmental radioactivity levels varying from place to place depending on the underlying natural radionuclides distribution. The focus of present study is use of a NaI (TI) scintillation survey meter to measure ground level Terrestrial Gamma Radiation Dose Rates (TGRD) in the Malaysian state of Negeri Sembilan (NS), also examining dependency upon underlying soil type and geological formations. The NaI (TI) scintillation system was chosen due to its ease of use, high sensitivity to environmental gamma radiation and the possible identification of inadvertent contamination. Studies have shown that the soil distributions and geological features influence TGRD (Ramli, 1997; Ramli et al., 2001; Malanca and Gaidolfi, 1996). However, based on local underlying soils distribution and geological age in NS, it was not known at the outset of this study how this might affect TGRD. Present information will add to existing base-line data, strengthen the ability to predict TGRD in the absence of full-scale ground level

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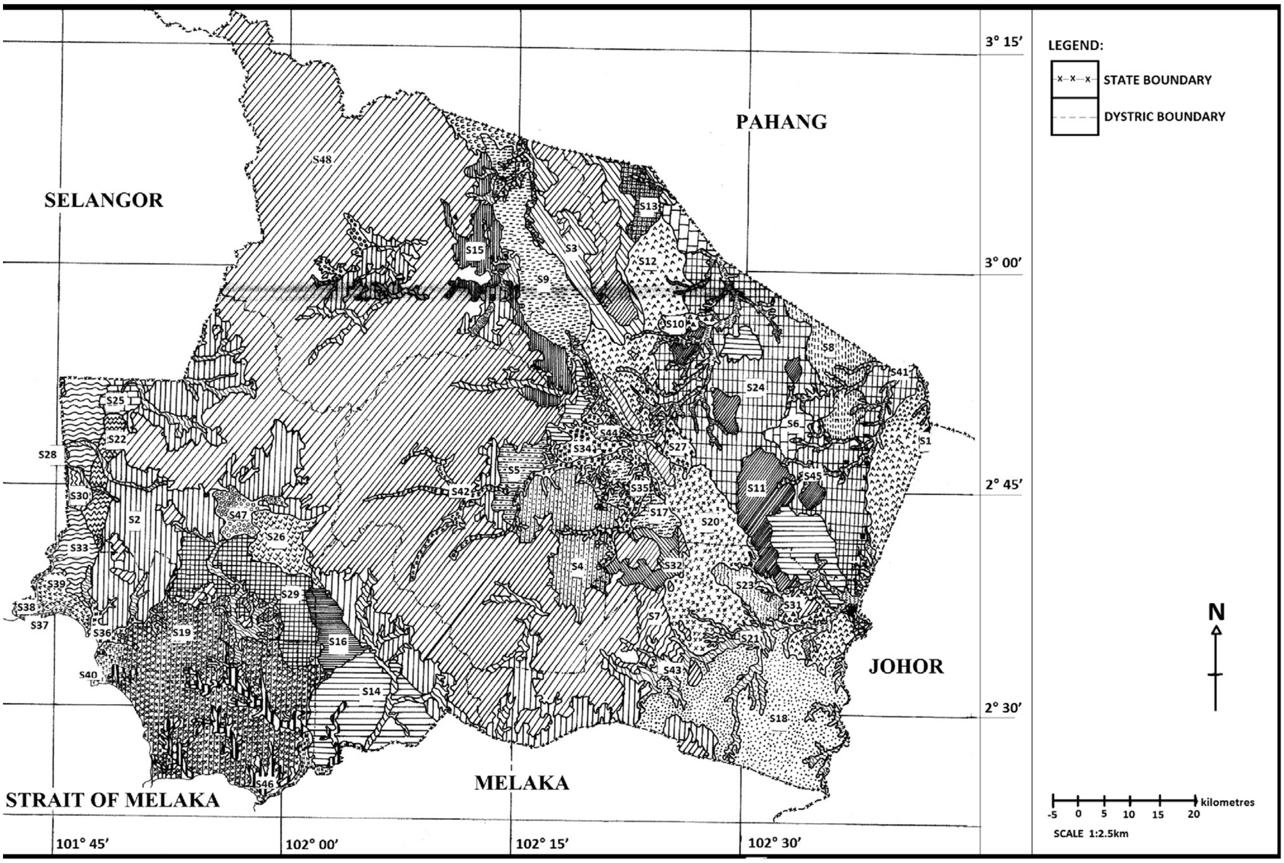
measurements and allow detection of the presence of radioactive contamination due to large-scale anthropomorphic-based events/ intervention. The scope of study focuses on natural radioactivity measurement covering NS, within the latitudes 2° 25′ N to 3° 15′ N and longitudes 101° 40′ E to 102° 45′, covering an area of approximately 6645 km^2 and a population of some 790,000.



S1	Geric Ferralsols-Rhodic Ferralsols	**S25**	Orthic Ferralsols-Dystric Leptosols
S2	Dystric Nitosols	**S26**	Orthic Ferralsols-Plinthic Ferralsols
S3	Dystric Nitosols-Haplic Acrisols	**S27**	Orthic Ferralsols-Ferric Acrisols
S4	Ferric Acrisols-Orthic Ferralsols-Batu Lapan	**S28**	Haplic Nitosols-Orthic Ferralsols
S5	Ferric Acrisols-Dystric Leptosols-Kedah	**S29**	Haplic Nitosols-Orthic Ferralsols-Rhodic Nitosols
S6	Orthic Acrisols-Plinthic Acrisols	**S30**	Haplic Nitosols-Ferric Acrisols
S7	Orthic Acrisols-Plinthic Ferralsols-Orthic Ferralsols	**S31**	Haplic Nitosols-Orthic Ferralsols-Plinthic Acrisols
S8	Orthic Acrisols-Plinthic Ferralsols-Rhodic Nitosols	**S32**	Dystric Leptosols-Orthic Ferralsols
S9	Ferric Acrisols-Plinthic Ferralsols	**S33**	Kedah-Dystric Leptosols-Orthic Ferralsols
S10	Ferric Acrisols-Plinthic Acrisols	**S34**	Dystric Ferralsols-Gleyic Acrisols-Akob
S11	Orthic Acrisols-Plinthic Ferralsols	**S35**	Haplic Acrisols
S12	Orthic Acrisols-Plinthic Acrisols-Plinthic Ferralsols	**S36**	Thionic Fluvisols
S13	Orthic Acrisols-Ferric Acrisols-Plinthic Ferralsols	**S37**	Thionic Fluvisols-Mangrove Swamp Association
S14	Plinthic Acrisols-Plinthic Ferralsols	**S38**	Thionic Gleysols-Thionic Fluvisols
S15	Plinthic Acrisols-Orthic Ferralsols	**S39**	Dystric Gleysols-Ocm
S16	Plinthic Acrisols-Dystric Leptosols	**S40**	Dystric Gleysols
S17	Plinthic Acrisols-Plinthic Ferralsols-Orthic Acrisols	**S41**	Riverine-Dystric Regosols
S18	Plinthic Ferralsols-Plinthic Acrisols-Rhodic Nitosols	**S42**	Riverine-Local Alluvium Association
S19	Plinthic Ferralsols-Rhodic Nitosols-Orthic Ferralsols	**S43**	Local Alluvium Association
S20	Plinthic Ferralsols-Plinthic Acrisols-Orthic Ferralsols	**S44**	Acob-Local Alluvium Association
S21	Plinthic Ferralsols-Orthic Acrisols	**S45**	Inland Swamp- Local Alluvium Association
S22	Plinthic Ferralsols-Orthic Ferralsols-Rhodic Nitosols	**S46**	Inland Swamp Association
S23	Plinthic Ferralsols-Rhodic Nitosols	**S47**	Disturb Land (DLD)
S24	Haplic Acrisols-Orthic Acrisols-Ferric Acrisols	**S48**	Steep Land (STP)

Fig. 1. Map of soil types covering of Negeri Sembilan (Director General of Agriculture Malaysia, 1973).